Controller Performance Evaluation of Fly-by-Feel (FBF) Technology

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Background

Fly-by-feel (FBF) is a new paradigm for safely maximizing aircraft stability and performance across a wide range of conditions wherein the aircraft autonomously and intelligently senses the aerodynamic environment and efficiently adapts the aircraft structure and control surfaces to suit the current mission objectives. FBF complements an integrated feedback approach to flight control, structural mode and load attenuation, and flow control. Desired flight performance, gust load alleviation and aerostructural stability in the presence of complex aeroservoelastic (ASE) uncertainties are met by utilizing aerodynamic observables in a robust control law framework. These observables include leading-edge stagnation point and critical flow features (separation, reattachment, reversal, shock, transition) measurable at the surface. In the Phase I effort we began investigating the effectiveness of the FBF approach in suppressing aeroelastic instabilities with a nonlinear ASE wind tunnel test model. Phase II work will ex- tend the results to the X-56A developed under an AFRL pro- gram with ultimate goals of improving aerostuctural performance (lift/drag/moment/load) with distributed FBF sensor- based flight control.

Approach

The primary objective is to provide a sound technical basis for determining the extent of performance improvement of the FBF approach under operational flight conditions in comparison to conventional flight control. Phase II objectives are to: (1) expand upon determining the relationship be- tween aerodynamic observables and aeroelastic performance, loads/moments, and control surface actuation with a nonlinear unconstrained pitch-and-plunge apparatus (PAPA) for a representative wing with regard to aeroelastic instabilities; (2) validate computational models predicting the aerodynamic coefficients (CL, CM & CD) based on pitch/plunge/actuator state and aerodynamic observables; (3) determine the accuracy/robustness of system identification techniques in capturing the nonlinear system parameters; and, (4) continue characterizing the performance of conventional and robust control laws using a variety of aerostructural sensors for feedback including aerodynamic observables in unsteady flows.

Flow bifurcation point sensors are being used as aerodynamic observables to estimate, in real-time without the delay of structural response, aerodynamic coefficients which will be used as direct aerodynamic force feedback for flight control resulting in minimization of ASE uncertainties. Sensors are integrated in a physics-based architecture that improves reliability, control effectiveness and robustness through a spatially distributed network.